



# Recovery of the Disrupted Quasi-Biennial Oscillation

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# Overview

Examine the 2015-16 Quasi-Biennial Oscillation Disruption and Recovery

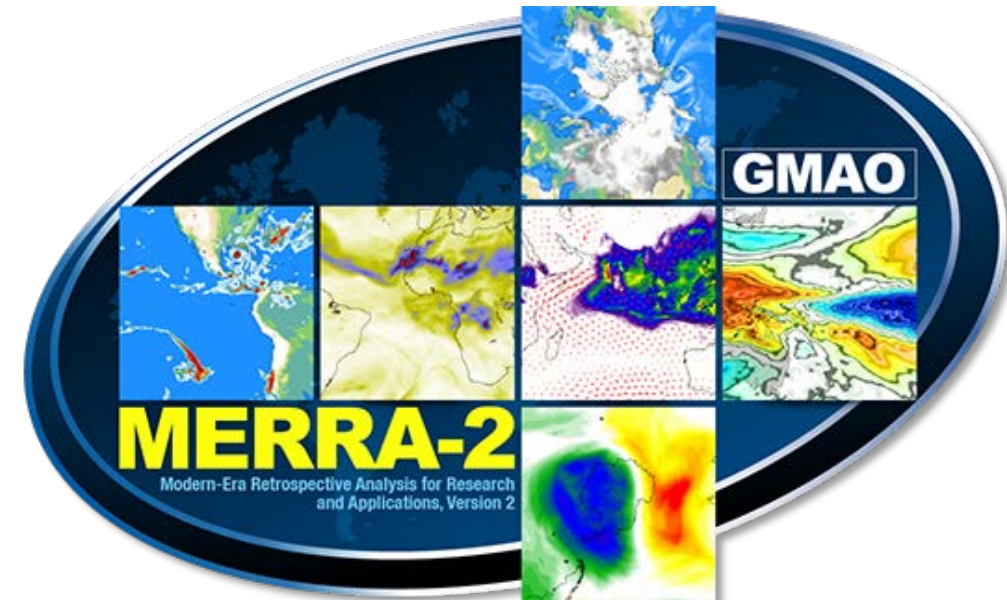
Global Winds from **MERRA-2**

Singapore Wind Soundings

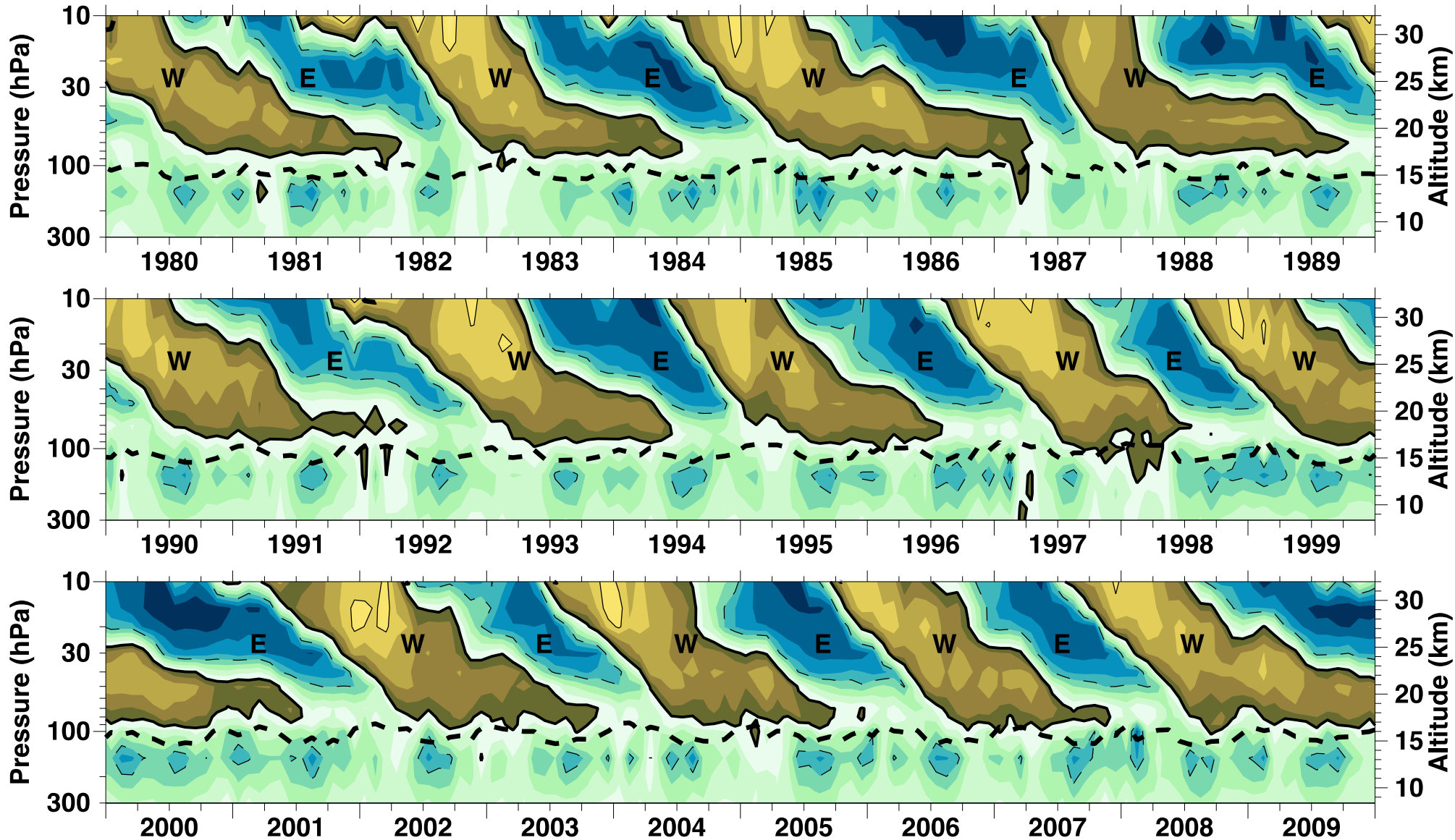
**Science Question:** Is the QBO Back to Normal?

## Modern-Era Retrospective analysis for Research and Applications, Version 2

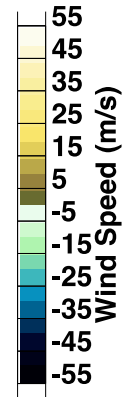
- Data beginning in 1980
- Assimilation of modern hyperspectral radiance and microwave observations, along with GPS-Radio Occultation datasets
- Advances in both the GEOS model and the GSI assimilation



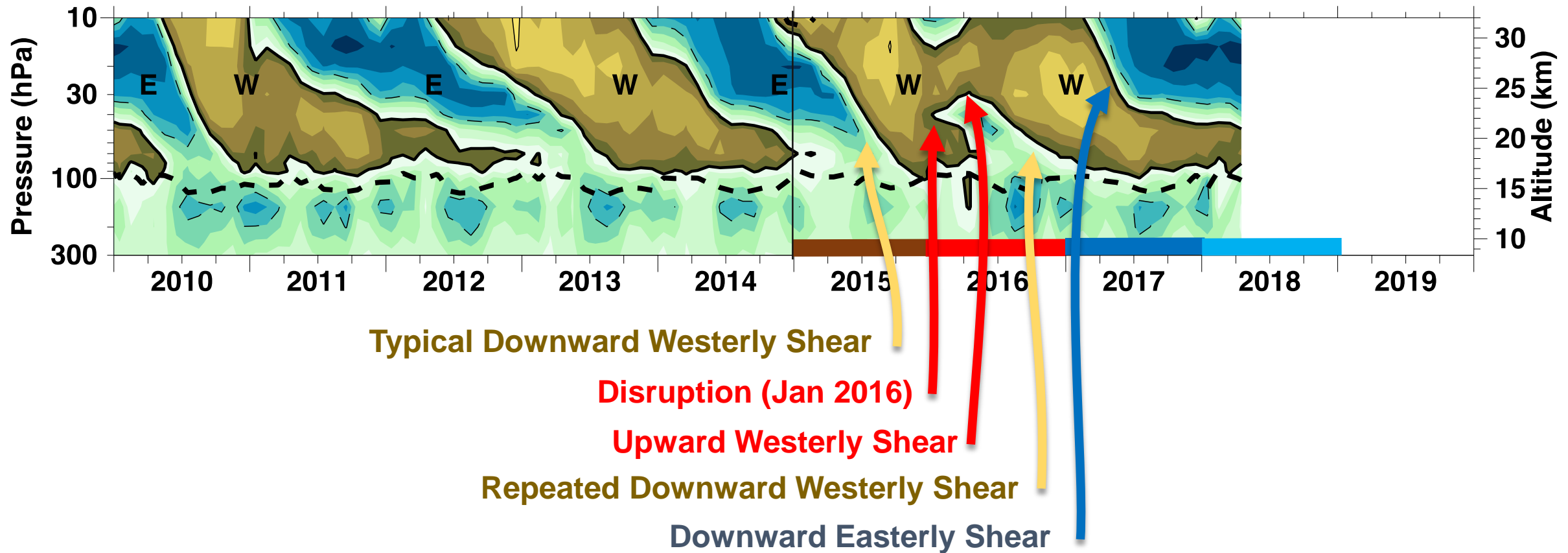
# Singapore Zonal Wind 1980-2009



**Quasi-Biennial Oscillation (QBO)**  
 Downward propagating easterly and westerly wind regimes.



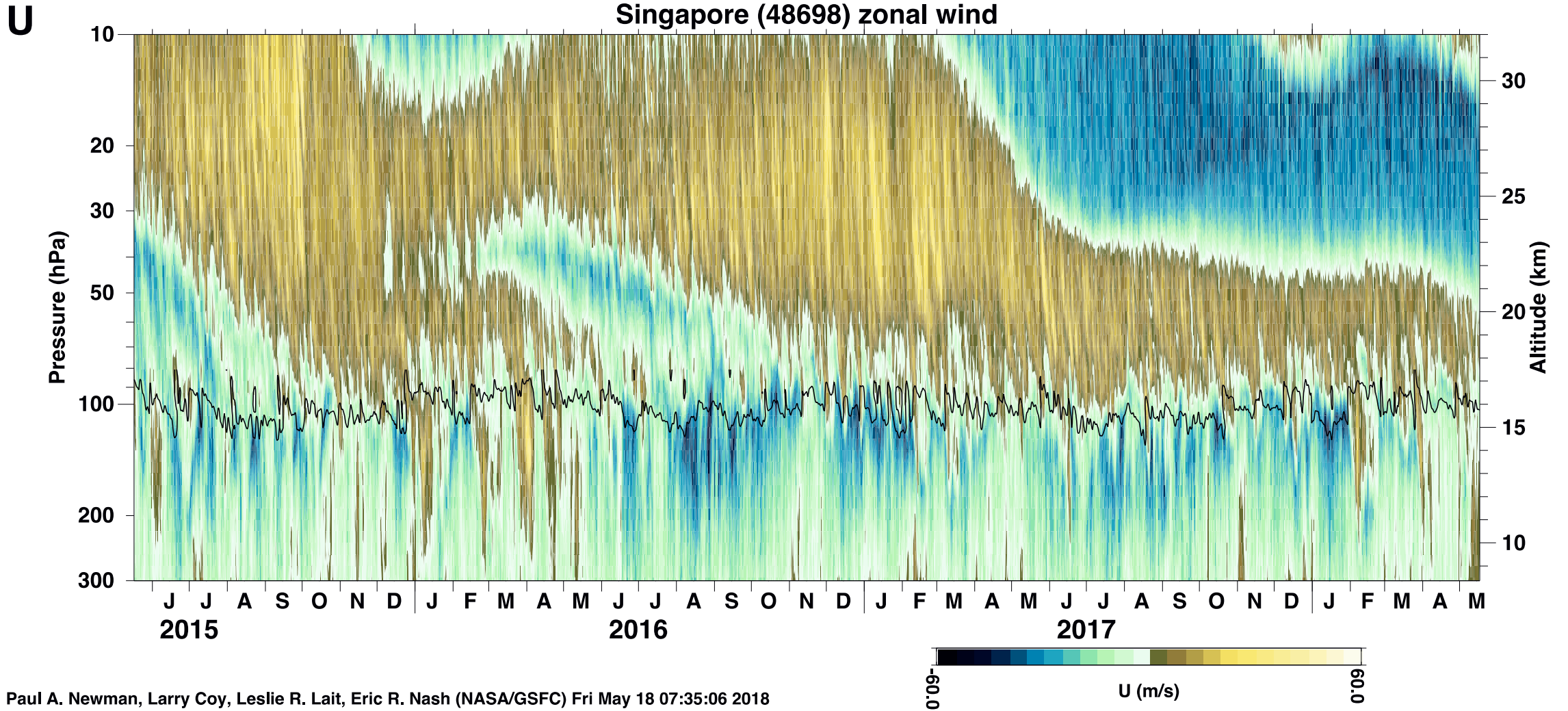
# Singapore Zonal Wind 2010-2017



## The Disrupted QBO



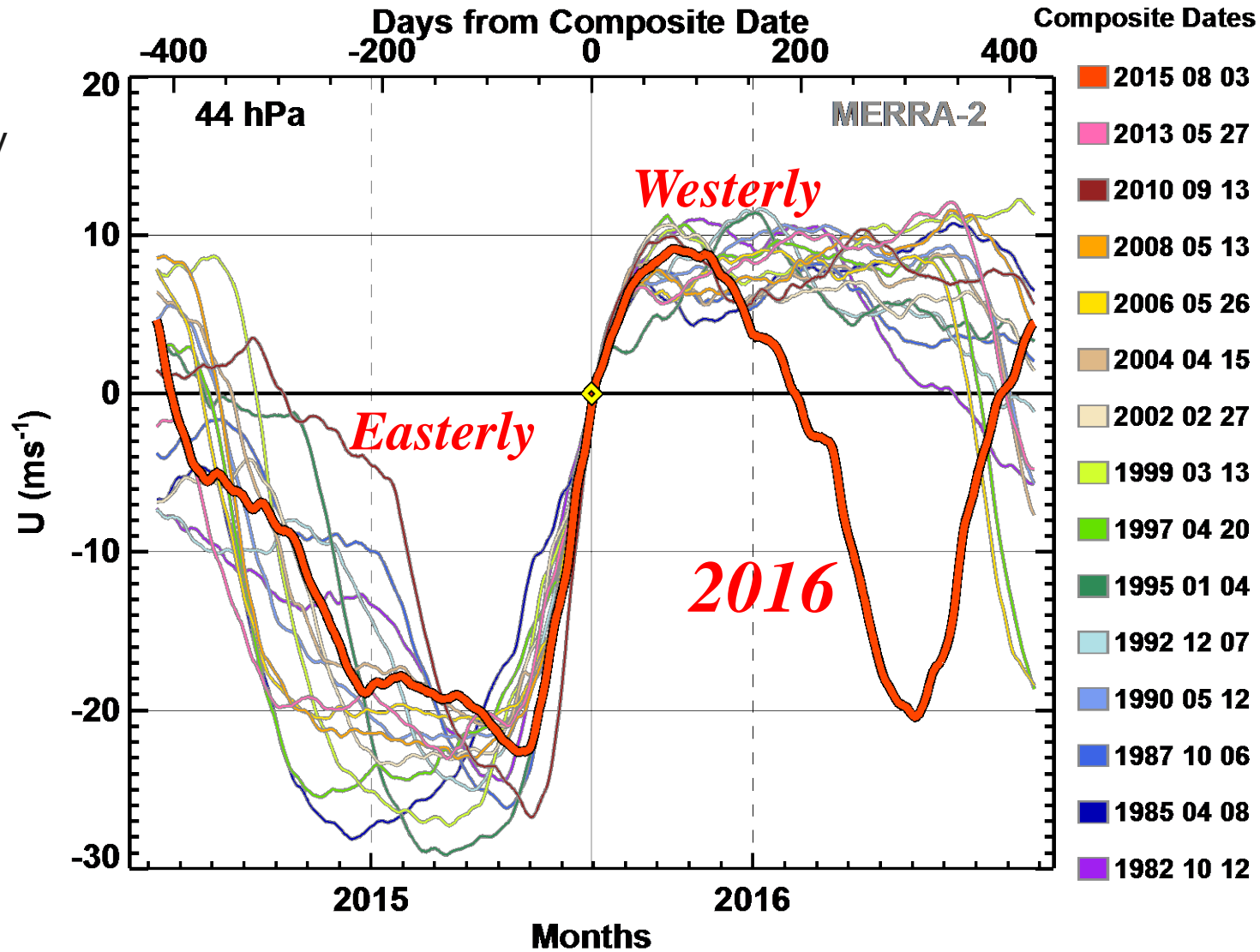
# Singapore Zonal Wind 2015-2018



Paul A. Newman, Larry Coy, Leslie R. Lait, Eric R. Nash (NASA/GSFC) Fri May 18 07:35:06 2018

# MERRA-2 Zonal Wind (44 hPa)

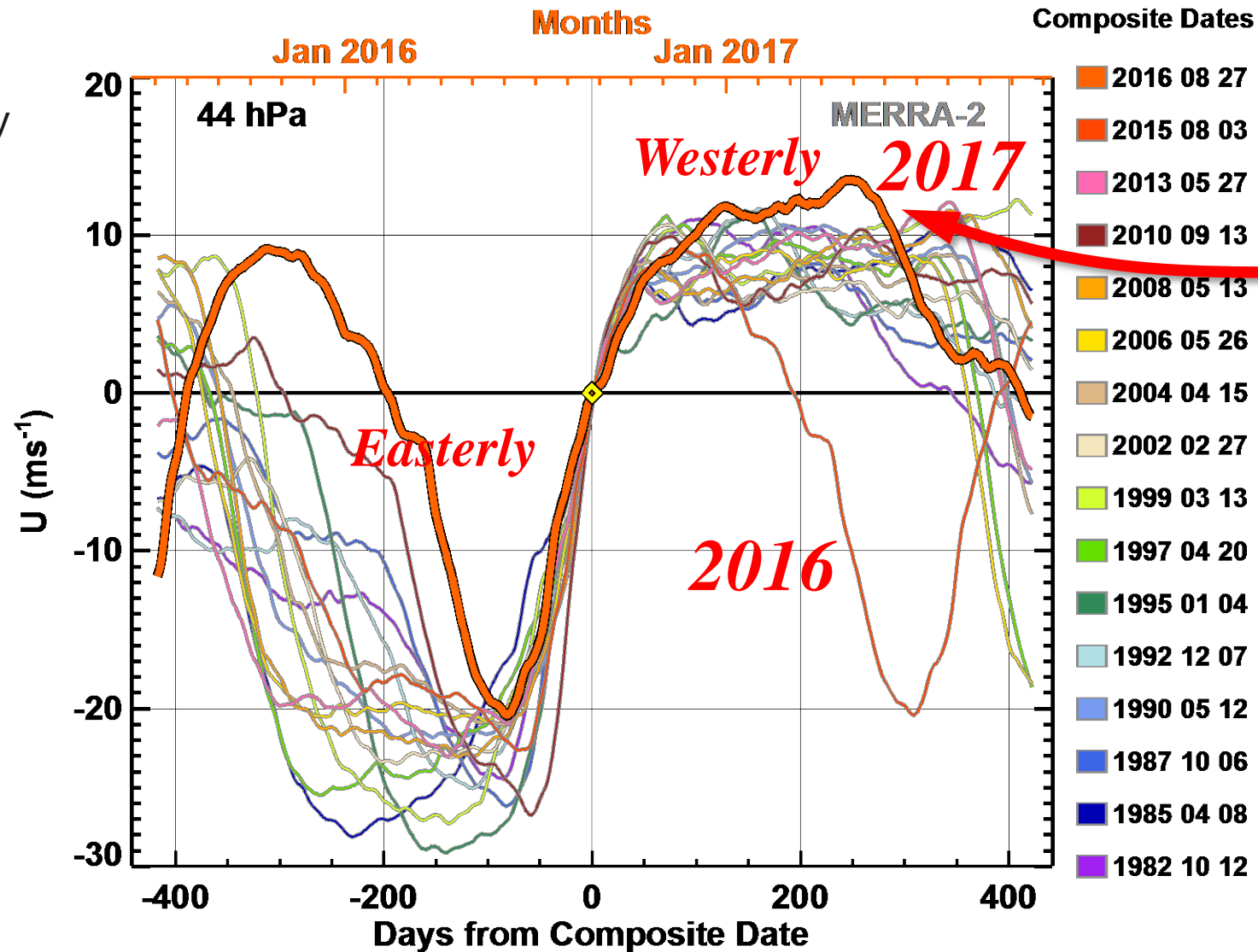
Composite on transition from easterly to westerly at 44 hPa





# MERRA-2 Zonal Wind (44 hPa)

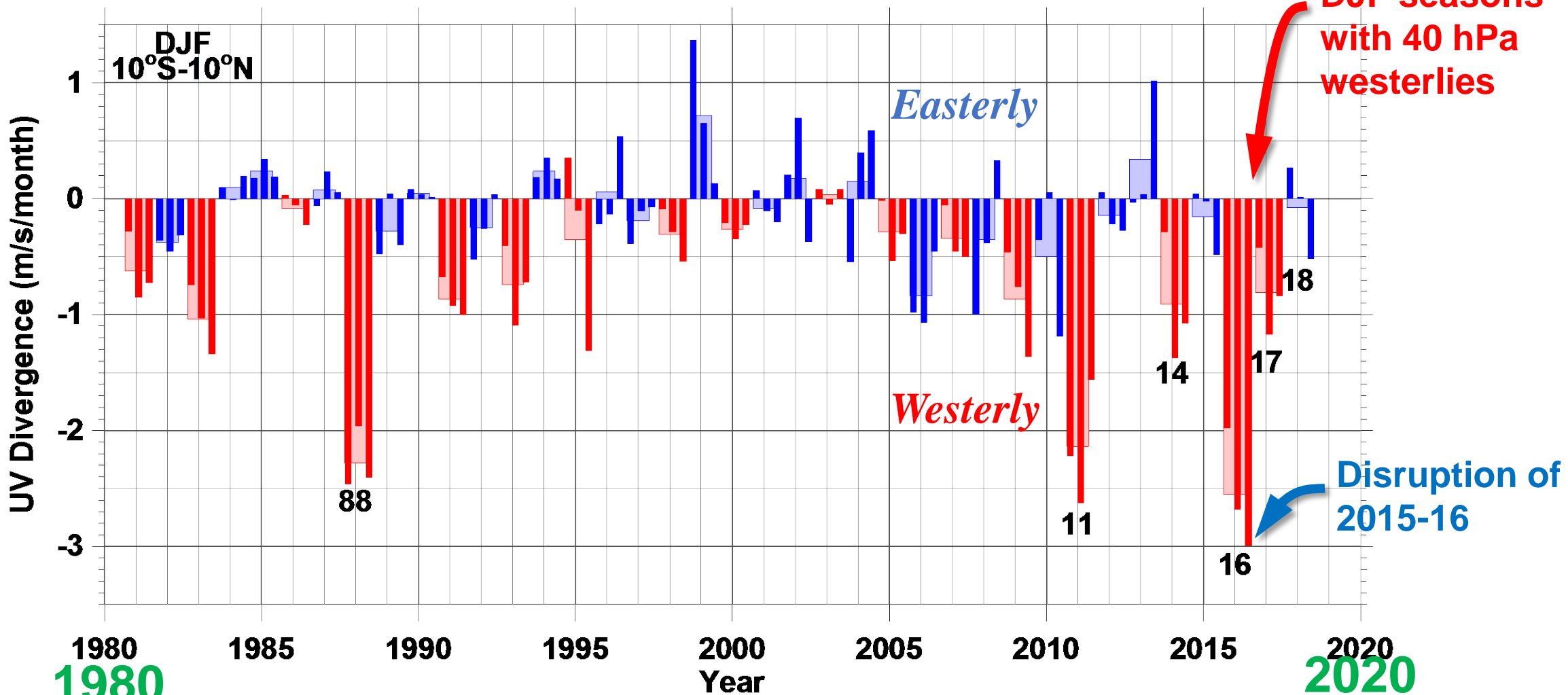
**Composite on transition from easterly to westerly at 44 hPa**



**Record strong westerlies at 44 hPa (MERRA-2)**

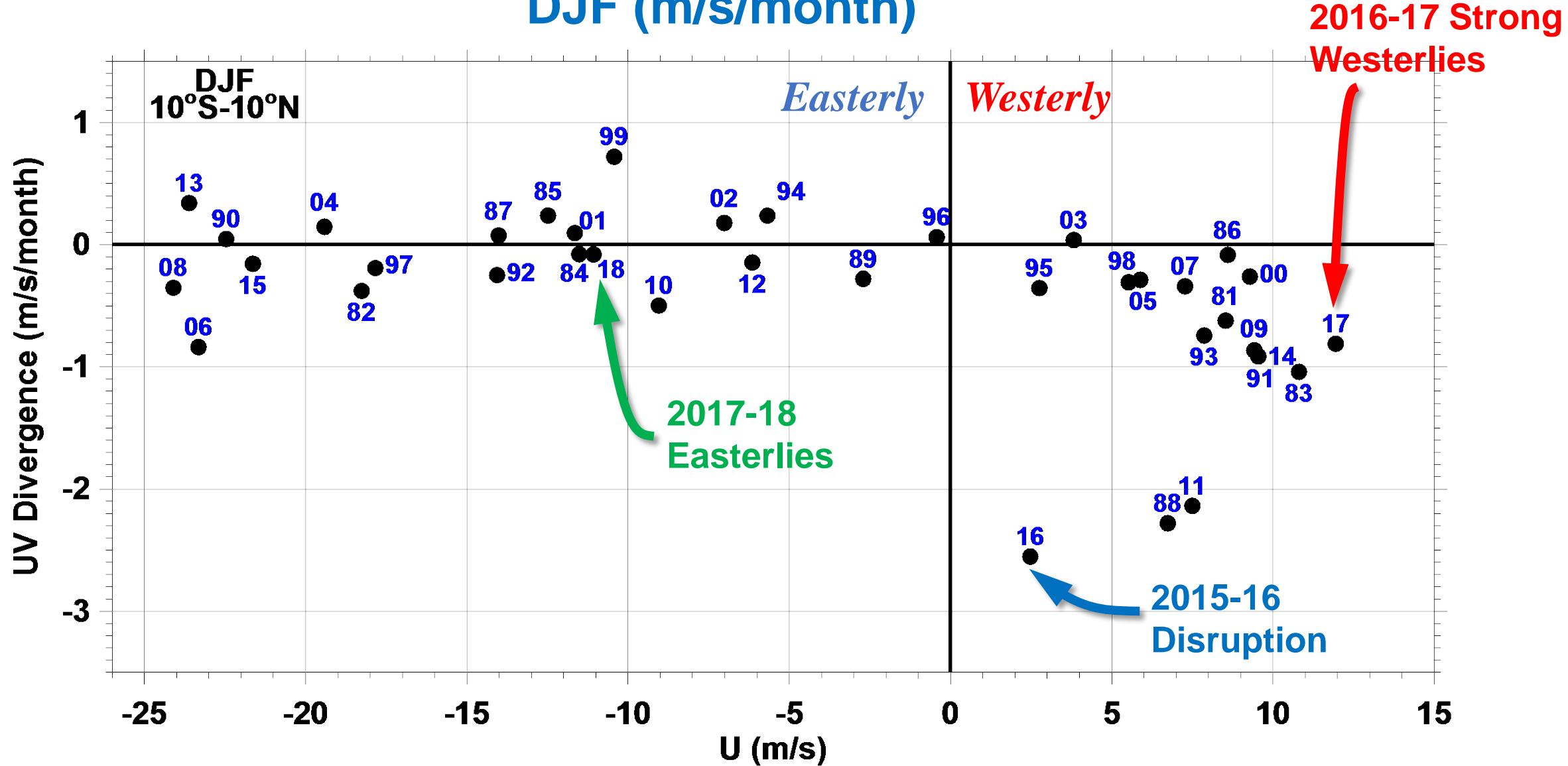


# Horizontal Momentum Flux Forcing (40 hPa) DJF (m/s/month)





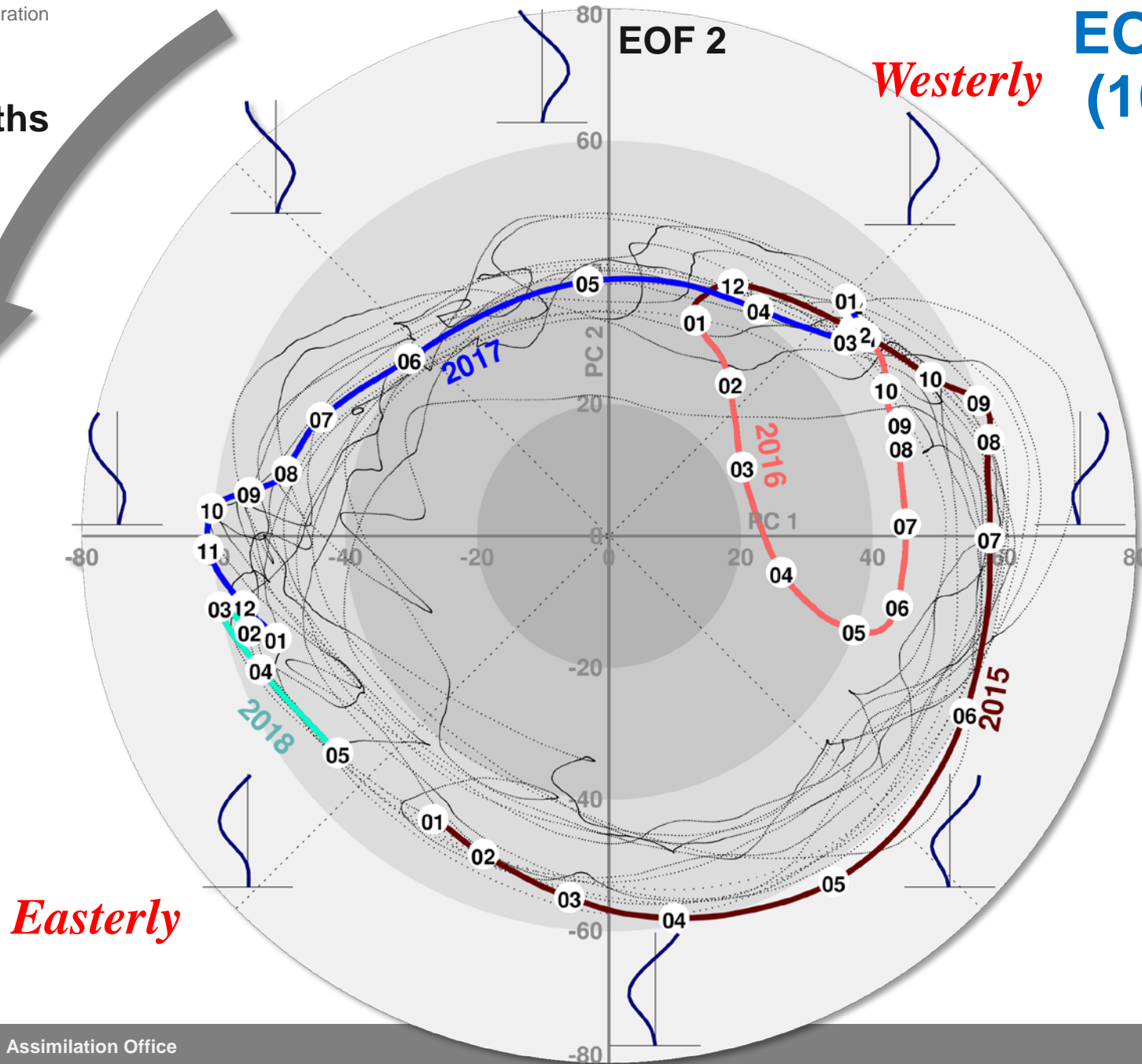
# Horizontal Momentum Flux Forcing (40 hPa) DJF (m/s/month)





# QBO Polar Diagram One circuit ~ 29 Months

# EOF Analysis (100-10 hPa)



EOF 1

EOF 2

*Westerly*

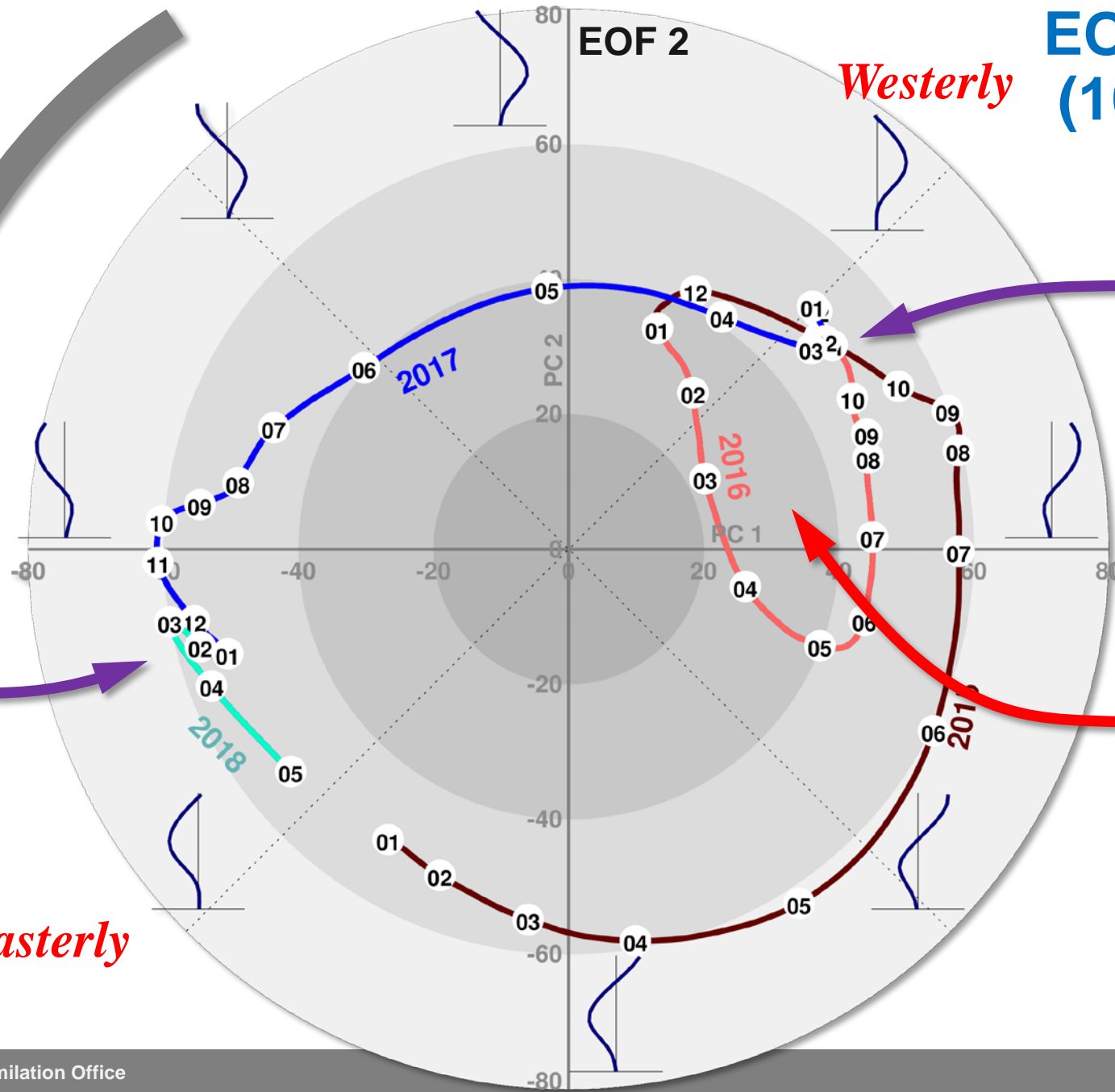
*Easterly*

**MERRA-2**  
Daily Averaged Winds  
Model Levels



# QBO Polar Diagram One circuit ~ 29 Months

# EOF Analysis (100-10 hPa)



Nov 2016 –  
Feb 2017  
Slow Down

EOF 1

2016  
Disruption  
Loop

MERRA-2  
Daily Averaged Winds  
Model Levels

Dec 2017 –  
Mar 2018  
Slow Down

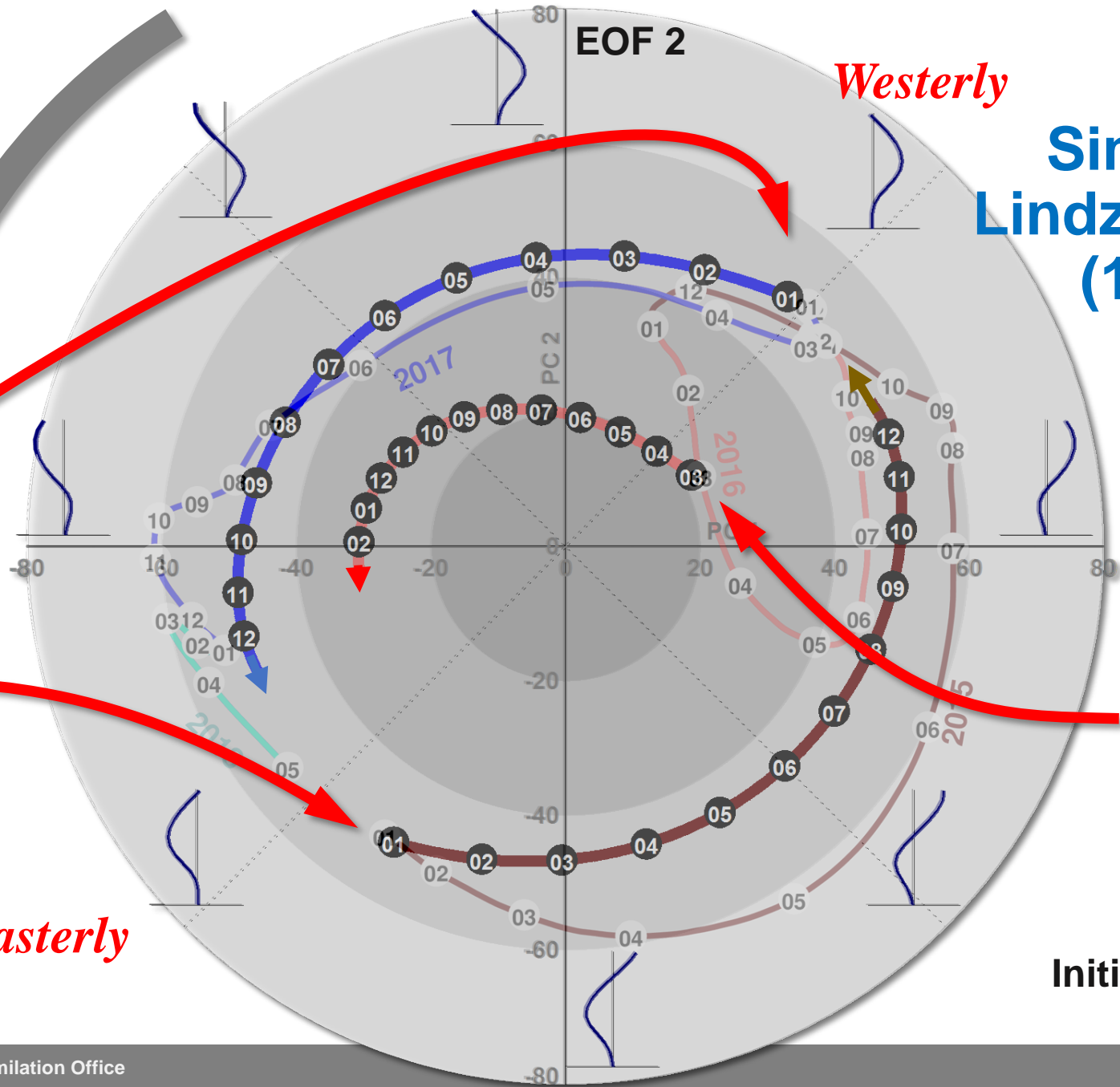
*Easterly*



# QBO Polar Diagram

One circuit ~ 29 Months

## Simple Holton-Lindzen QBO Model (100-10 hPa)



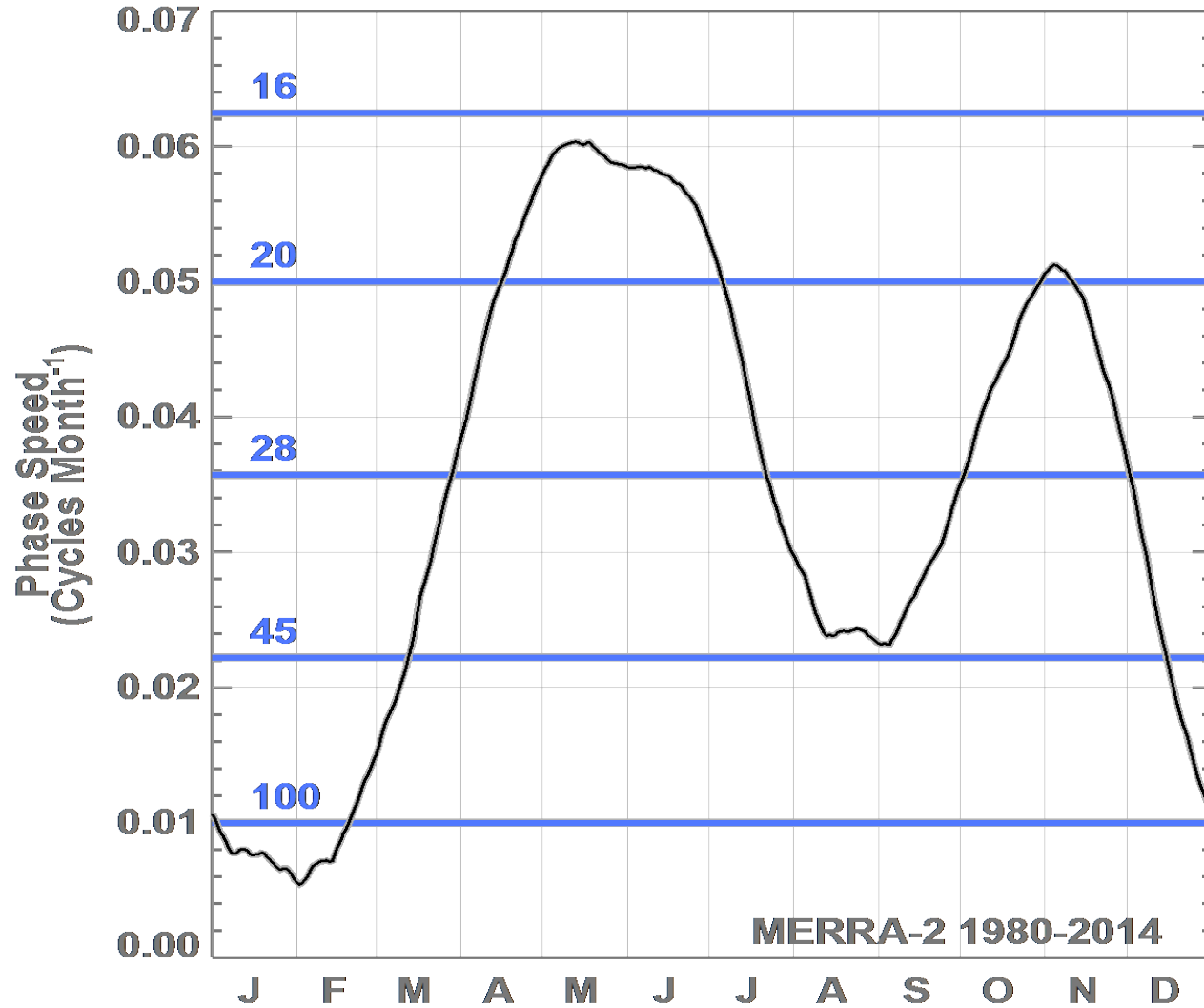
**2017 Initialization**

**2015 Initialization**

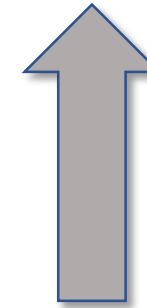
**2016 Does not track disruption**

Initialized from MERRA-2

# Annual Cycle of QBO Descent (Composite)



Faster Descent



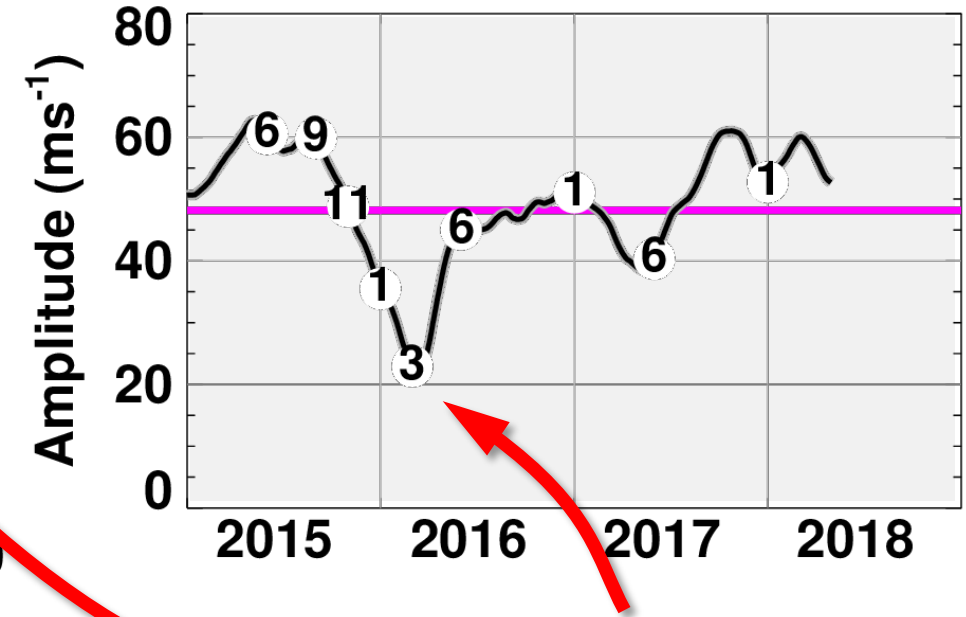
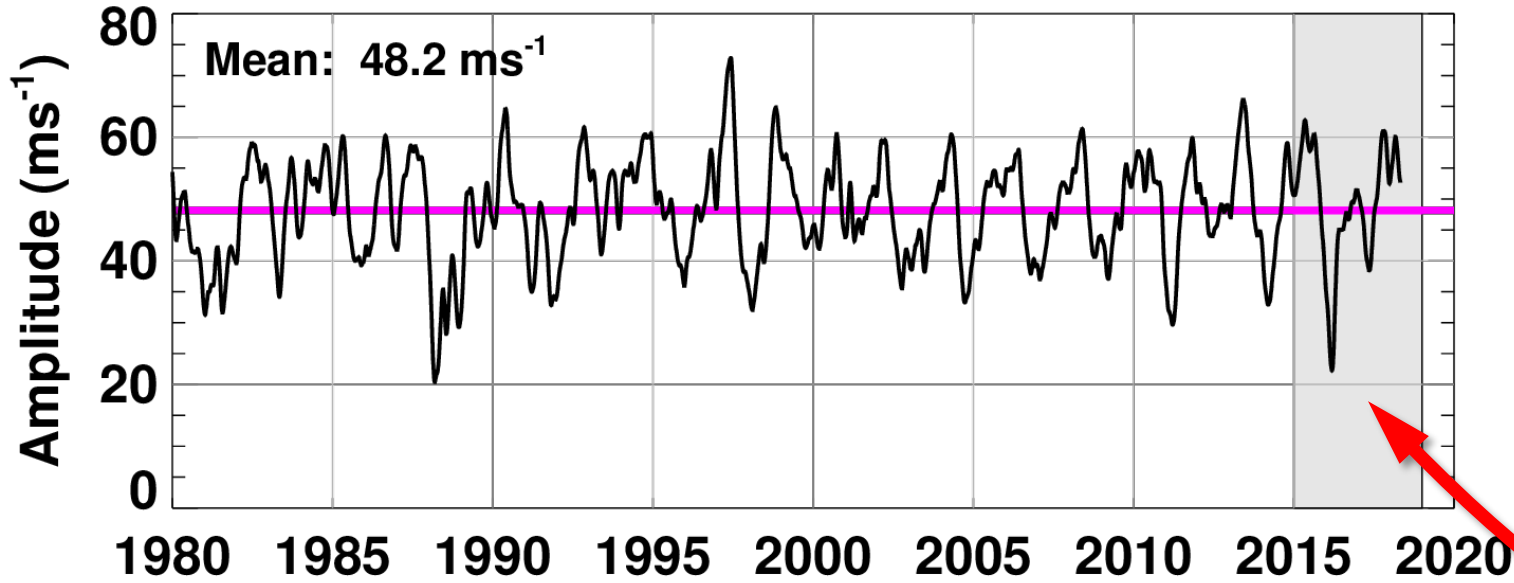
28 Month Descent Cycle



Slower Descent

Winter Planetary Waves Increase the Brewer-Dobson Circulation, Slowing the QBO Descent

# Amplitude of Principle Components 1 and 2 1980-2018

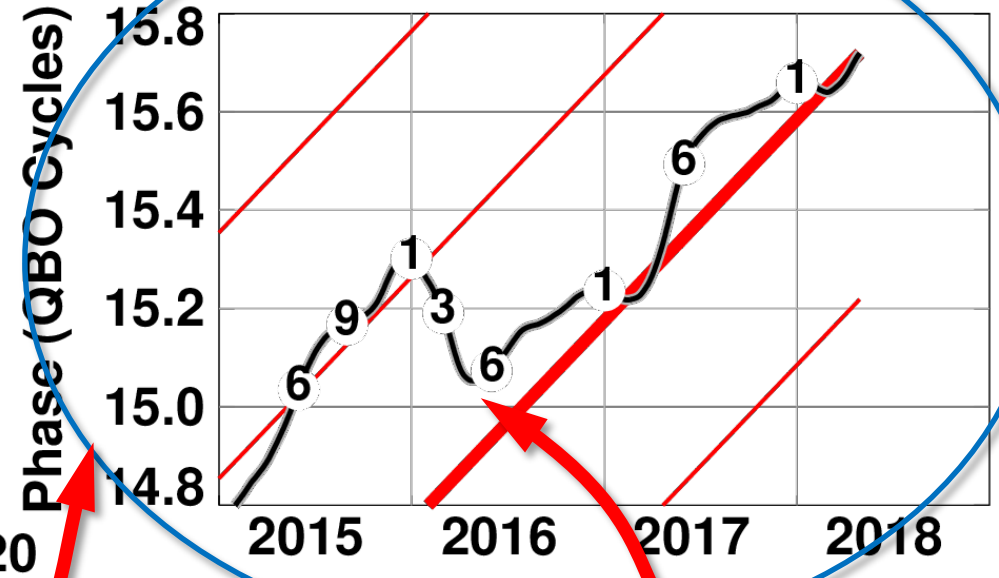
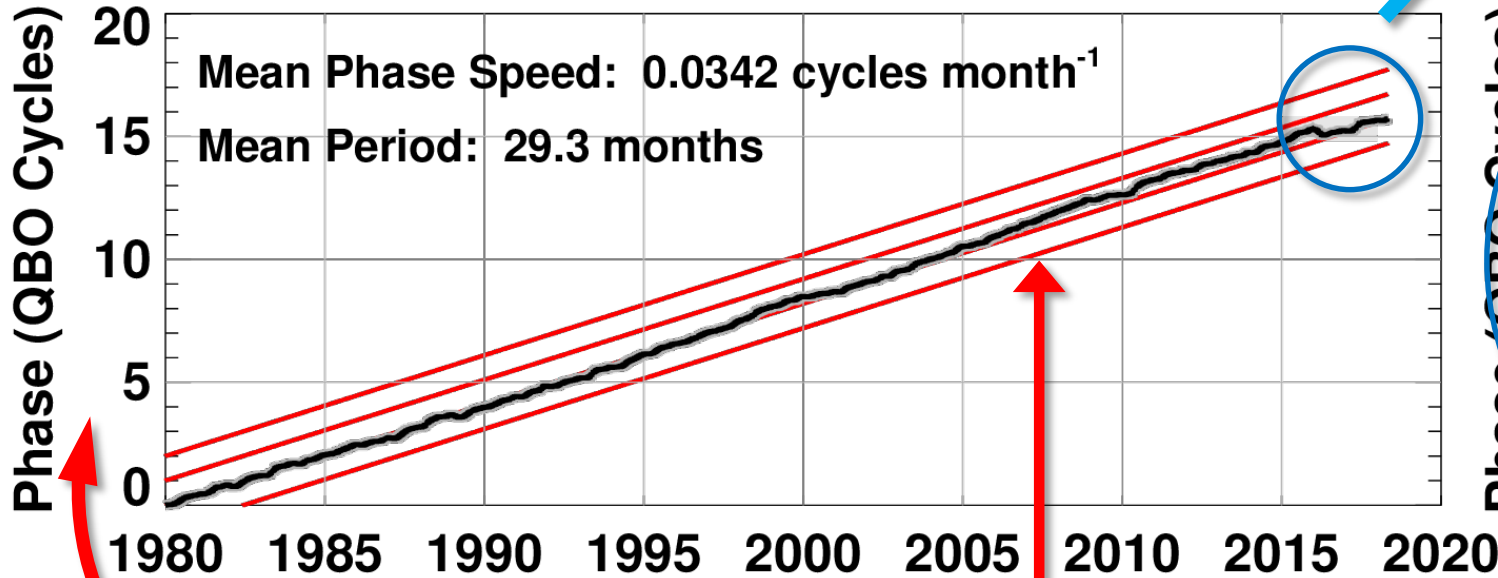


Amplitude is the summed projection of the vertical wind profile onto the 1<sup>st</sup> two EOFs.

**2015-2016  
Disruption**

MERRA-2 --- Daily Averaged Winds --- Model Levels

# Phase of Principle Components 1 and 2 1980-2018



Number of QBO cycles since 1980: 15+

One QBO Cycle

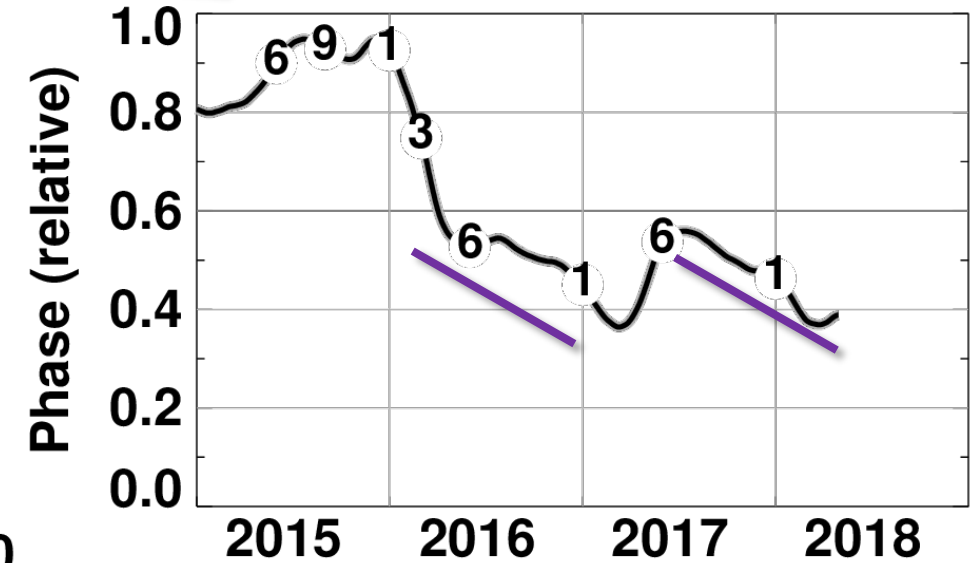
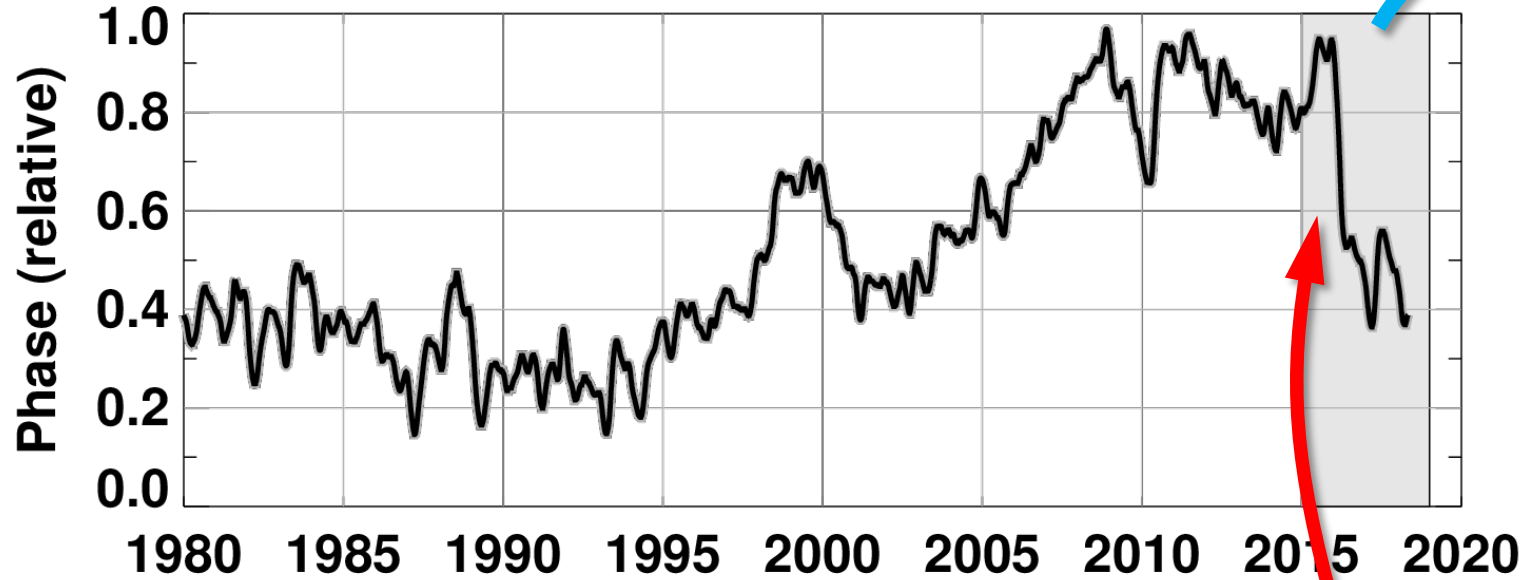
2015-2016 Disruption

Red Lines are the Linear Fit

Disruption Phase Shift:  $\sim 1/2$  QBO Cycle

# Phase of Principle Components 1 and 2 1980-2018

Phase with constant linear increase removed



Positive Slope: Faster QBO Descent  
Negative Slope: Slower QBO Descent

2015-2016  
Disruption

Strong Annual Slowing of the  
QBO Descent in 2016 and 2017





# Conclusions

Examine the 2015-16 Quasi-Biennial Oscillation Disruption and Recovery  
Global Winds from **MERRA-2**

**Science Question:** Is the QBO Back to Normal? **YES!**

**But...**

The disruption (non-typical descent) lasted about 6 months and returned the QBO to the 6 month previous phase, creating a QBO cycle that lasted approximately a year (~50%) longer than the average period. This delay created back to back NH winters with QBO Westerlies. **Cause: Still under study**

Unusually Strong Westerlies were found in the lower stratosphere following the disruption. **Cause: Unknown**

The past two NH winters 2016-17 and 2017-18 have experience a strong slowing of the QBO descent. **Significance: Unknown**

## Thank You